Taylor Diagram Software

Please consider these formulas for Standard Deviation:

$$\sigma_o = \sqrt{\frac{\sum\left(O_i - \overline{O}\right)^2}{N}}$$

$$\sigma_M = \sqrt{\frac{\sum\left(M_i - \overline{M}\right)^2}{N}}$$

Where σ_O, and σ_M is standard deviation of observation and model. $\overline{O}$, and $\overline{M}$ is average of observation and model. N is number of samples.

Now I want to describe the Taylor Diagram formula. The statistic most commonly used to quantify differences between two fields is the Root Mean Square Error (RMSE), denoted as RMSE, which is defined for fields O and M by the formula below:

$$RMSE = \sqrt{\frac{\sum(O_i - M_i)^2}{N}}$$

The centered RMSE is:

$$CE = \sqrt{\frac{\sum\left[(O_i - \overline{O}) - (M_i - \overline{M})\right]^2}{N}} \Rightarrow$$

$$CE^2 = \frac{1}{N} \times \sum[(O_i - \overline{O})^2 + (M_i - \overline{M})^2 - 2(O_i - \overline{O})(M_i - \overline{M})]$$

$$= \frac{1}{N} \times \left[\sum(O_i - \overline{O})^2 + \sum(M_i - \overline{M})^2 - 2\sum(O_i - \overline{O})(M_i - \overline{M})\right]$$

$$= \sigma_O^2 + \sigma_M^2 - 2\left[\frac{1}{N} \times \sum(O_i - \overline{O})(M_i - \overline{M})\right]$$

If we express the formula for Pearson correlation in terms of the standard deviation of the observation and model data, we get:

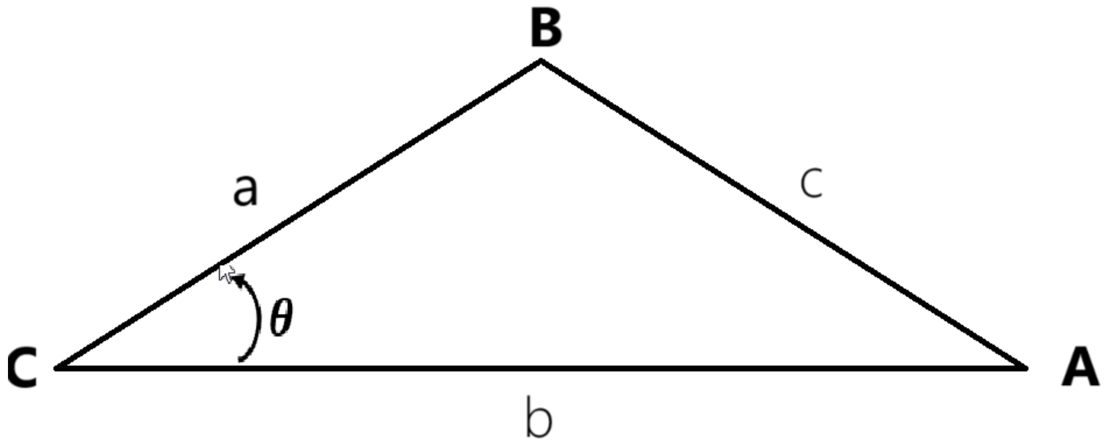
$$R = \frac{\frac{1}{N} \times \Sigma[(O_i - \overline{O}) \times (M_i - \overline{M})]}{\sigma_O \sigma_M} \Rightarrow$$

$$\sigma_O \sigma_M R = \frac{1}{N} \times \sum[(O_i - \overline{O}) \times (M_i - \overline{M})] \xRightarrow{CE\ formula}$$

$$CE^2 = \sigma_O^2 + \sigma_M^2 - 2\sigma_O \sigma_M R$$

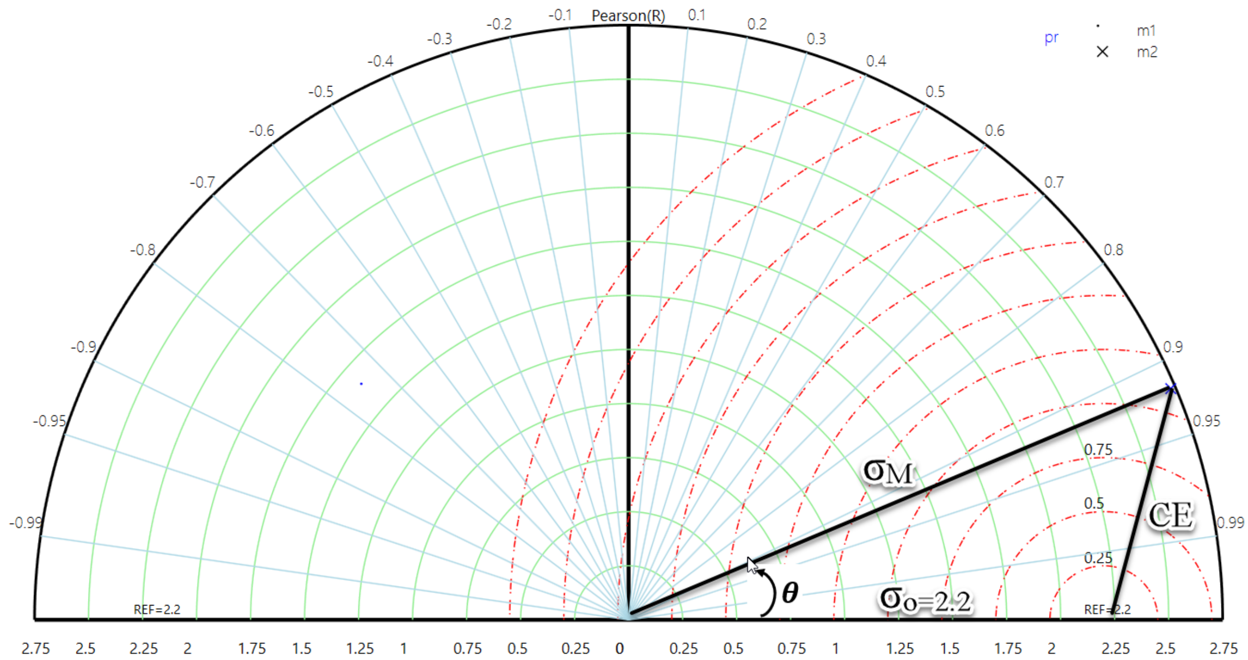
The construction of the Taylor diagram is founded on the similarity between the equation mentioned above and the Law of Cosines, which is as follows:

$$c^2 = a^2 + b^2 - 2ab\cos\theta$$



We consider c to be CE (centered RMSE) and a to be σ_M and b to be σ_o. Consequently, Pearson correlation R can be expressed as $\cos\theta$.

With these substitutions, all the elements are represented in the figure below. In this diagram, the green circles denote the standard deviation of the model, the red circles represent the centered RMSE (CE), and the black circle axis represents the Pearson correlation coefficient (R). The REF point on the horizontal axis corresponds to the standard deviation of the observation. Please note that if the R-value is positive, the point will be located in the right quarter-circle. Conversely, if the R-value is negative, the point will be situated in the left quarter circle.



Normalized and Classic Taylor Diagram

Due to the potential disparity in numerical values among different variables (e.g., precipitation, temperature), it's necessary to normalize the results with respect to reference variables. This normalization process involves calculating the ratio of normalized variances, which effectively conveys the relative amplitudes of the model and observed variations. A normalized Taylor diagram and a Classic Taylor diagram are both graphical tools used in meteorology and climate science to assess and compare the performance of models or datasets in replicating observed data. However, they differ in how they represent and emphasize certain aspects of the comparison:

1. Representation of Standard Deviation:

- Classic Taylor Diagram: In a Classic Taylor diagram, the radial distance from the center of the diagram represents the standard deviation of the model or dataset (σ_M). This means that models or datasets are compared based on their variability relative to the observed data.

- Normalized Taylor Diagram: In a normalized Taylor diagram, the radial distance represents the normalized standard deviation (σ^*) of the model or dataset. The normalization is achieved by dividing the standard deviation of the model (σ_M) by the standard deviation of the observed data (σ_o). This accounts for differences in amplitude and scale between the model and observed data, emphasizing how well the model replicates the variability relative to the observations.

$$\sigma^* = \frac{\sigma_M}{\sigma_O}$$

2. Emphasis on Standard Deviation and Correlation:

- Classic Taylor Diagram: In a Classic Taylor diagram, the focus is on standard deviation and correlation. It provides a straightforward comparison of how well models or datasets match the observed data in terms of variability and linear relationship (correlation).

- Normalized Taylor Diagram: In a normalized Taylor diagram, the emphasis is on assessing model performance while considering differences in scale. It provides a more balanced evaluation by taking into account both the variability (σ^*) and correlation (R) relative to the observed data.

3. Reference Point:

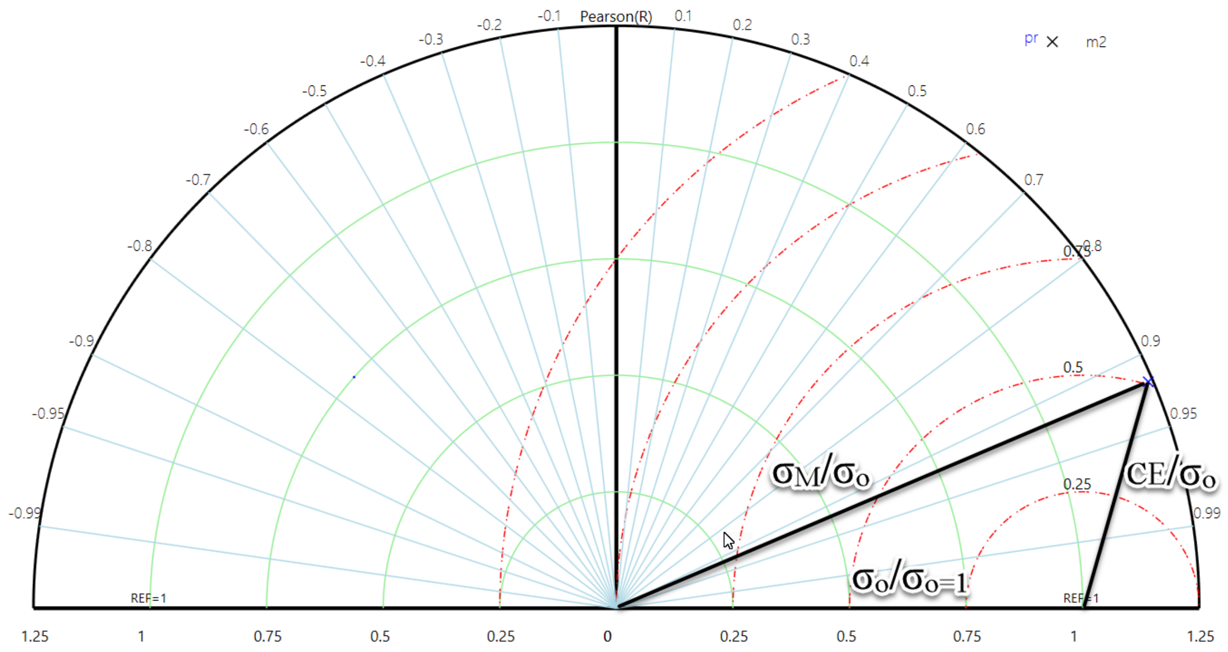
- Classic Taylor Diagram: The reference point in a Classic Taylor diagram is often located at the observed standard deviation (σ_o, 0.0) on the polar plot.

- Normalized Taylor Diagram: The reference point in a normalized Taylor diagram is typically located at (1.0, 0.0), representing a perfect match in terms of both standard deviation and correlation. This reference point helps assess how well the model replicates the observed data while accounting for differences in scale.

In summary, the main difference between a normalized Taylor diagram and a Classic Taylor diagram lies in how they handle and emphasize the standard deviation and the consideration of scale differences. Normalized Taylor diagrams provide a more comprehensive assessment of model performance by normalizing the standard deviation, making them particularly useful when comparing datasets or models with different units or ranges of values (For example comparing several variables on a chart). Classic Taylor diagrams offer a simpler view, focusing primarily on standard

deviation and correlation. The choice between them depends on the specific needs of the analysis and the characteristics of the data being compared.

In Normalized Taylor Diagram the items will change as below figure:



References:

1- Summarizing multiple aspects of model performance in a single diagram

2- Taylor Diagram